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Water Erosion in Alberta

BY

J. A. TOOGOOD AND J. D. NEWTON
Department of Soils

Distributed by
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UNIVERSITY OF ALBERTA
COLLEGE OF AGRICULTURE

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TABLE OF CONTENTS

LIST OF TABLES

SUMMARY OF
CONTROL METHODS FOR ALBERTA

1. Follow a good crop rotation aimed at maintaining or building up the organic matter and fibre content of the soil. Grass and legume crops should be included, especially in the moister regions of the province.

2. Avoid summerfallowing in the moister regions of Alberta, except when needed to control certain perennial weeds such as couch grass.

3. Maintain a trash cover if possible when land is not in crop.

4. Avoid overworking and pulverizing the soil. When possible use implements such as the one-way, cultivator, rod-weeder, and blade weeder, which leave the trash on top and do not pulverize the surface soil.

5. Conserve all crop residues. Do not burn straw or stubble.

6. Seed down waterways that are likely to wash, using a hay mixture including grass.

7. Keep steep slopes in permanent grass or tree cover. Re-grass or re-forest steep slopes where necessary.

8. Practise strip cropping across slopes of cultivated fields that tend to wash severely. Contour cropping may occasionally be required.

9. Plant cultivated row crops across rather than up and down slopes that tend to wash.

10. Plow and cultivate across rather than up and down slopes that tend to wash. A ridged surface left in the fall across a cultivated slope will tend to check spring run-off.

11. Grow cover crop or winter crops, when practicable, on fields that are likely to be damaged by spring run-off.

12. Spread straw or barnyard manure on slopes where washing is likely to occur, and dam runways with straw, brush, stones, or other material where gullying is apt to occur.

13. Adopt special control methods for specialized areas. Mangum terraces, for example, may occasionally be desirable in Alberta.

14. Encourage community effort to control soil erosion. Control measures may be ineffective if neighbors do not adopt similar methods.

It is evident that a number of the methods used for water erosion control will control wind erosion also.

This soil of ours, this precious heritage,—what an unobtrusive existence it leads! While the lush carpet of grass conceals it, the beauty and splendor of flowers and trees distract our attention from it. To the rich soil let us give the credit due. The soil is the reservoir of life. Here the smallest seeds find shelter and the urge for germination and growth; here live in countless varieties, myriads of micro-organisms, busy with their alchemies of life; here dwell the lowly earthworms, a leaven of the fields; here are the minerals, calcium, phosphorus, nitrogen—a list of fifteen or more—which plants, and animals, and man in turn, must have for their well-being. And like any other reservoir this one too can be drained and left empty and useless,—let but the winds and the rains strike at the fallowed fields; let but the naked soil be exposed to the elements—how soon and how tragic the loss. The fruits of countless ages vanish; impoverished fields, livestock, and people take their place. How selfish the man, how short-sighted his view, who does not cherish and protect this heritage in his care!

—J. A. Toogood.

PREFACE

The problem of water erosion is not a new one. The Greeks recognized it two thousand years ago, and many other civilizations have experienced its threat but it has received attention in the United States and parts of Canada only during the last thirty years. In the Prairie Provinces the emphasis has been placed on wind erosion and many practical methods of control have been developed. Ontario has had under way for several years some experimental projects aimed at the study of water erosion but in Western Canada only a little work has been done.

The Department of Soils here at the University since 1942 has been collecting soil samples from virgin and cultivated slopes in an effort to find by analyses the effects of water erosion in Alberta. Except for this analytical work and reporting eroded areas in soil survey bulletins and suggesting the accepted control methods, the efforts of the Department have been directed towards other problems which seemed more pressing. During the last two years, however, a program of research dealing solely with water erosion has been started and the time now appears to be ripe for an initial report. The report is brief and presents only a small amount of experimental evidence. Revisions from time to time will be made as more data are gathered.

Principles of water erosion are discussed briefly and an attempt is made to assess the water erosion problem in Alberta. Control methods are described and their suitability to our conditions discussed. It is hoped that the bulletin will clarify the problem in the minds of those who have the responsibility of protecting our most valuable natural resource—the soil—from the ravages of water erosion.

The authors are indebted to the Alberta Soil Survey for the use of several of their photographs depicting erosion. Further acknowledgment is made of the use of meteorological data published by the Meteorological Division, Department of Transport. The City of Edmonton, Engineer's Department, and the Dominion Meteorological Office at Edmonton have also been helpful in supplying data and information.

SUMMARY

Meeting the problem of water erosion in Alberta demands first a consideration of principles governing erosion, then a survey of precipitation data for the province, and finally experimental evidence in order that suitable control methods can be selected.

Geological and Accelerated Erosion

The normal loss due to erosion of soil from slopes that still support their native plant cover is referred to as geological erosion. It may be considered of some value in that it brings the subsoil closer to the surface and replenishes the supply of minerals vital to plant and animal life.

Where the native plant cover is removed, however, and cultivated crops and fallows substituted the rate of soil loss increases rapidly and accelerated erosion results. This is a serious problem. Top soil is much more fertile than subsoil and losses of only a few inches may seriously reduce yields of crops.

Principles of Water Erosion

The principles governing water erosion fall into three categories: rainfall characteristics, field characteristics and soil properties.

With regard to rainfall we are concerned not only with total rainfall, but also with the intensity of fall in particular intervals of time. Rain drops have a pulverizing action on exposed soils, liberating the clay, silt and fine sand particles and permitting them to be carried away in suspension in the run-off water.

Characteristics of the field such as steepness and direction of slope, and the nature of the protective cover determine to a large degree the amount of erosion that will take place.

With respect to the soil itself soil structure is the dominant factor because it determines infiltration rate and erodibility. Soil structure in turn depends upon the relative amounts of sand, silt, and clay, the quantity and nature of organic matter, the method of handling the soil, the chemical nature of the soil, and so on.

Precipitation Studies in Alberta

Annual precipitation in Alberta's crop growing areas varies from 14 to 20 inches, 70 to 80 per cent of which falls during the six months April to September. Total rainfall in the crop growing period is not high compared to conditions elsewhere, and the erosion problem is therefore not so acute.

A study of the few records available indicate that rainfall intensities in Alberta are also low compared to those experienced in areas where water erosion is a serious problem.

These studies suggest two extreme views which we in Alberta must guard against. first, we must not think that all methods suitable for control of serious erosion elsewhere should be used here; second. we must not assume that our water erosion problem is negligible and can be disregarded.

Erosion Plot Studies

Erosion plots were established at St. Albert by the Soils Department of the University in 1949. Eight plots on a 12 per cent slope are designed to study the effects of crop cover, crop rotation, and intensity of rainfall on amount of run-off and soil loss Data collected in 1949 and 1950 show that the percentage of storms causing erosion was low and that where run-off did occurr rainfall and soil losses were not severe Data for several years will be needed, however, to warrant sound conclusions in this project

Relative losses from plots with different plant covers followed expected trends, the water and soil loss being least from the native sod plot and greatest from the summerfallowed plot. Losses from plots with cereal grain cover were less severe than from the fallow plot, but varied considerably according to the thickness of stand.

Analyses of Soils Subject to Erosion

Virgin and cultivated soils subject to erosion were analyzed in an effort to demonstrate the effect of erosion. Determination of total nitrogen and total phosphorus content showed a decrease in the former as a result of cultivation. in line with earlier studies here and elsewhere, but no consistent trends could be noted resulting from erosion. This was probably due to the wide variety of soil types used in the study

Analyses of Soils Not Subject to Obvious Erosion

Extensive investigations were made concerning the effects of the grain and fallow system of farming on the composition of soils that had not been obviously eroded

In a period averaging 22 years, the losses in percentage of nitrogen and organic matter from the surface 6 inches of brown, dark brown, and black soils were much alike on the average, and amounted to about 18 to 20 per cent of the original content. However, in the case of the grey wooded soils these losses amounted to about 30 per cent.

Although the percentage losses were similar in the brown, dark brown and black soil zones, the total losses of organic matter and nitrogen increased with increase in original organic matter content in all zones.

It was estimated that on the average about one-third to one-half only of the nitrogen lost could have been taken up by the crops, and it appears likely that wind and water erosion cause losses when their effects are not readily observable

The losses of organic matter and nitrogen are evidently greatest after the land is first broken and tend to decrease in later years where the land is not obviously eroded.

Control Methods for Alberta

For a summary of control methods suitable for Alberta refer to page iii above

Water Erosion in Alberta

by

J. A. Toogood and J. D. Newton

INTRODUCTORY

Geological Erosion

Erosion by water is a geological process occurring in all countries wherever rains fall and snow banks melt. Every year the mountains, the hillsides, and the slopes are worn down and the seas, lakes, valley and watercourses gradually filled with water-transported materials. Under most conditions the rate of erosion is slow because the plant cover of trees, shrubs, and grass serves as a shield and a blotter protecting the soil beneath, but if the plant cover is inadequate serious damage may result. See Figure 1.

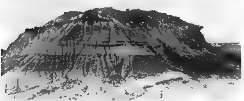


Figure 1.- Severe geological erosion in the Red Deer valley near Drumheller. Vegetation has been unable to protect the soil from erosion on these steep slopes and most of the topsoil is now lost.

This erosion, occurring under natural conditions, we call geological erosion. Agriculturists recognize and accept this type of erosion and do not consider it a serious problem, but think of it instead as a process that may be actually beneficial. Soil is formed from the products of the weathering of subsoil and in order that this weathering process may take place air and water must be available. Geological erosion, by washing away the topsoil at a very gradual rate, allows the weathering processes to move downward, thus leading to the formation of new soil. The process of soil formation

is a slow one, estimates for the formation of an inch of topsoil varying from a few hundred to several thousand years.

Accelerated Erosion

The problem arises when man steps into the picture. In his efforts to gain a livelihood at lumbering or farming or at some other industry he clears the land. Seldom does he restrict his efforts to level areas, but attacks the slopes and the hills. The protective cover is cleared away and the soil beneath exposed. Now a serious kind of erosion takes place, called by the geologist accelerated erosion, in which the forces holding the soil in place weaken and the precious topsoil is carried away more and more rapidly to the rivers and thence to the sea. The clearing of the land permits rapid run-off which often leads to the cutting of gullies. This is the kind of erosion with which the agriculturist is concerned because topsoil is a valuable natural resource that must not be wasted. See Figure 2.

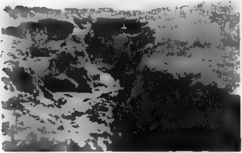


Figure 2.—Accelerated erosion. This gully in the Dunchester area was the result of a single storm.

Historians, studying the rise and fall of ancient civilizations, endeavour to account for the causes of their decline. One cause frequently mentioned is the decline in agriculture resulting from misuse of the land. Some historians go so far as to claim that soil erosion was one of the primary causes of the fall of such ancient civilizations as those of Mesopotamia, Phoenicia, Greece, Italy, and Libya. We may disagree if we like with these conjectures as to the

past, but we must face the facts before us today. Reports published by the United States government show that 50 million acres of former cropland in that country are now essentially destroyed for tillage due to disregard of water erosion. That is roughly twice the area of land under cultivation in Alberta today. Another 225 million acres in the United States have been severely eroded. On totalling the areas moderately eroded, severely eroded, and destroyed, we find that about 55 per cent of the total area of the country is affected. There is no question about the seriousness of erosion in parts of the United States and the Government has taken steps to solve the problem. In Canada the Province of Ontario is actively engaged in erosion survey and control. The Department of Planning and Development has completed careful surveys of selected watersheds with the object of improving land use, conserving soil and controlling run-off.

What then is the situation in Alberta? Are we in danger too? Are we taking adequate precautions? In seeking answers to these questions let us first review briefly the principles governing water erosion and then go on to analyze the situation in Alberta.

PRINCIPLES OF WATER EROSION

Rainfall Characteristics

Amount and Intensity

Both total amount and rate of precipitation are important. Small rainfalls of course seldom cause serious erosion although amounts as low as a few tenths of an inch may produce run-off under certain conditions. Of more importance than the amount of rainfall is the intensity or rate at which the rain descends. This is usually expressed in inches per hour. An inch of rain falling in fifteen minutes (that is at the rate of 4 inches per hour) produces more run-off and erodes more soil than the same amount of rain falling over a period of several hours. The main factor determining the intensity above which run-off occurs is the infiltration rate of the soil, the speed with which water can soak into and down through the soil. Since infiltration rates of soils vary widely, the critical intensities will likewise vary. Many of the factors mentioned below also enter the picture.

Corresponding to intensity of precipitation we have in the spring the parallel problem, rate of run-off of the melting snow. In the Edmonton area in 1950 the run-off was slow lasting several days, and there was little or no gullying and only small soil losses. In other years the major portion of the snow melted in one or two days and with the subsoil still frozen there was a large and rapid run-off

which cut gullies and washed away some of the topsoil. A quick thaw does not give the soil a chance to thaw out and thus there is little infiltration. See Figure 3.

Rain as a Dispersing Agent

Rain acts in two ways to cause erosion. First it pulverizes the soil, second it carries away the fine soil particles in suspension. The pulverizing action is often disregarded in dealing with water erosion. Soil particles are normally grouped together into small lumps or aggregates and held together by the cementing action of clay and organic matter. As long as these aggregates remain intact they are large enough to resist movement by flowing water but when pulverized as by a beating rain, the small particles are easily washed away. Hail for example exerts a strong pulverizing action and some of our worst soil erosion occurs during the summer hail storms. Fine, misty rains, being low in intensity and exerting little pulverizing action rarely cause erosion.

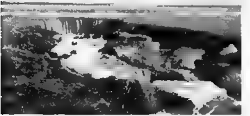


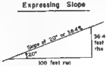
Figure 3.—Spring run-off in the Barons district. Rapid melting of snow in the spring leads to gullying like this unless watercourses are given special attention.

Field Characteristics

Slope

First might be mentioned the effects of topography on water erosion. The lay of the land is very important. In speaking about the slope of a hill there is occasionally some misunderstanding as to the meaning of degree and per cent slope. The measurement of a slope in degrees refers to the size of the angle measured vertically between the horizontal plane and the surface of the hill. This is illustrated for a given slope in Fig. 4. In determining the per cent

slope we express the tangent of this angle as a per cent, or putting it in a carpenter's terms, we express the ratio of rise over run as a per cent. This is shown in Fig. 4 for a slope of 20 degrees, and the accompanying table gives the per cent slopes corresponding to other angles of elevation. Thus we may say that a particular hillside has a slope of 20 degrees or of about 36 per cent. Examination of the table shows that a slope of 45 degrees is a 100 per cent slope and that a slope of over 100 per cent is quite possible.



Degrees	Per cent
0°	0%
5	8·75
10	17·63
15	26·79
20	36·40
25	46·63
30	57·74
35	70·02
40	83·91
45	100·00
50	119·18

Figure 4.—Methods of expressing slope and table showing corresponding values

Effect of Slope

The steeper the slope the more rapidly the water flows of course. Roughly speaking, the velocity is doubled when the per cent slope is quadrupled, and doubling the velocity of flowing water increases its erosive or cutting capacity four times, the quantity of material of a given size it can carry thirty-two times, and the size of particle it can roll or push along sixty-four times. The risk involved in cultivating steep slopes is thus quite apparent.

In addition to the per cent of slope, erosion is also concerned with length of slope. The longer the slope the greater the volume of water accumulating and flowing down over it. Experiments have shown that the per cent of precipitation that runs off varies not only with the length of slope but also with rainfall intensity, soil characteristics, and degree of slope. Thus some data show that under certain conditions per cent run-off and soil losses increase with length of slope, while under other conditions run-off and soil losses decrease with length of slope. Most of the data indicate that degree of slope is more important than length of slope in determining the losses. Corresponding to length of slope we might mention size or area of watershed. A watercourse which has to take all the run-off from spring thaw and heavy rains over a large acreage is bound to erode and form a gully sooner or later.

Infiltration Rate

The slope of a field has little or no effect on the rate of infiltration, that is, the speed at which water soaks into the soil. It is the

nature of the soil itself—moisture content, porosity texture, structure that determine the speed with which rainfall soaks down into the soil. A dry, finely pulverized soil prevents rapid infiltration (a strong argument against the use of dust mulches) while a moist soil quickly absorbs additional moisture. Starting with a moist soil, however, it has been shown that higher moisture content results in a lower infiltration rate. Porosity refers to the amount of pore space or air space in the soil and is determined by texture and structure. While clay soils have a greater total pore space than sands, the individual pores are smaller, and as a result infiltration rates through clay soils are usually lower than through sandy soils. This general rule may be modified by the structure of the soil which refers to the degree and manner in which soil particles are cemented together to form aggregates. Some clay soils may thus have a high infiltration rate due to the presence of large stable aggregates. Degree of slope has no effect on these properties of the soil hence no effect on infiltration rate.

Protective Cover

By far the most important characteristic of a field in determining erosion losses is its plant or trash cover. A mat of leafy, bushy plant material, as in an alfalfa-brome grass mixture, forms a canopy that protects the soil. The force of the falling raindrops is absorbed by the leaves, thus preventing pulverization of the soil aggregates. The mass of dead leaves and plant materials at the soil surface acts like a sponge absorbing and holding large amounts of water. Finally the plant cover retards the flow of run-off water, and with the decrease in velocity of flow there is a rapid drop in erosive powers. All kinds of crops will not give the same amount

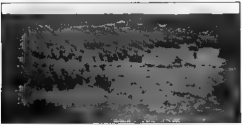


Figure 5.—Cereal crops do not give complete protection from erosion as shown by the erosion in this field near Warner.

of protective cover Grain crops with their narrow erect leaves are less efficient than the clovers and other broad-leaved bushy plants (see Figure 5), row crops are still less efficient, stubble is of some value if thick enough and assisted by a mat of combine straw, a trash cover is much better than no cover at all

The direction in which a field slopes has some effect on erosion losses. In the first place, the type of soil usually differs—soils that have formed on north-facing slopes are usually different from those formed on south-facing slopes. Secondly spring run-off is more rapid from the south slopes Thirdly the rainfall intensity is affected by the direction of the slope with respect to wind-driven rains—for a storm approaching from the north, the north-facing slopes would receive a more intense rain than the south-facing slopes.

Soil Characteristics

Texture

Soil texture refers to the relative amounts of sand, silt and clay present Clay particles are those smaller than 0.002 mm. (or about $^1/_{12500}$ inch), sand particles are those greater than 0.05 mm. (about $^1/_{500}$ inch) silt particles are in between these limits. With few exceptions, soils contain mixtures of all three sizes and the proportions of each determine the soil class—loam, sandy loam, silty clay, and so on These different soil classes differ widely in their erodibility Clay particles, being the smallest, are most readily carried by running water, but usually clay particles in the soil are tied up with organic matter and other soil particles into large aggregates, the clay and organic matter acting as cementing agents. Thus soils that are high in clay are not always the most erodible soils. Where poor soil management pulverizes the soil and destroys the organic matter, thus destroying the aggregate structure, heavy clay soils erode easily of course Sandy and silty soils seldom have a well-aggregated structure because organic matter and clay content are usually low so that the aggregates are poorly cemented. Hence these soils are easily dispersed and apt to wash badly On the other hand, the large size of the coarser sand fractions offers more resistance than silt or clay particles to movement by water, and in addition coarse textured soils have a high infiltration rate so that sandy soils do not always suffer the greatest losses. Silty soils are usually the most erodible, the particles being readily transported, aggregation usually poor and weak, and infiltration rate low

Structure

We have already mentioned the structure of the soil. This is probably a more important characteristic of soils than texture, not

only from the point of view of erosion, but also in connection with the growth of crops. By structure we refer to the extent and nature of the clumping together of sand, silt, clay and organic matter particles. If the aggregates are well cemented together we speak of a strong structure; if they are easily crumbled we say the structure is weak; if the aggregates are small and somewhat round in shape we have granular structure; if they are flat or flake-like we use the term platy structure. Many other terms are used by the soil scientist to describe the various kinds of soil structure, but we are concerned here only with the relation of structure to erosion, a relationship that has many aspects. First, a soil with weak structure is readily dispersed and the fine materials washed away, while strong aggregates resist pulverization; second, the extent to which clay and silt particles are clumped together into stable aggregates determines the amount of material already dispersed and readily washed away; third, the kind of soil structure affects the per cent of air space in the soil and this porosity in turn determines rate of infiltration; fourth, the aggregates themselves being porous absorb moisture, so the nature of these aggregates fixes the amount of water that can be absorbed and the rate of absorption.

Chemical Composition

The chemical composition of the soil enters the picture too. The cementing properties of the clays are largely affected by the nature of the minerals of which they are composed. The water absorbing power of some clay minerals is very high while for others it is relatively low. Some clay minerals expand or swell when moistened and when present in a soil prevent infiltration. These clays on drying contract more than others. The organic matter and humus content of a soil may be considered under the term chemical composition. Organic matter refers to all those materials in the soil which originated in plant or animal life, carbon and nitrogen being important constituents. Humus refers to those products of organic matter decomposition which strongly resist further change and decompose very slowly. Black in color, humus not only gives the characteristic color to the top soil, but also is a very important cementing agent in aggregate formation. All forms of organic matter in the soils, particularly crop residues, have high water-holding capacities. High organic matter content therefore means less run-off and less erosion. The kind and amount of soluble salts in soils affect percolation rates by affecting the dispersion of aggregates.

Moisture Content

Another characteristic of the soil affecting erosion is its moisture content at the start of a given storm. If the soil is low in moisture content more water will be absorbed faster and thus there will be lower losses from erosion than if the soil is saturated. Our Alberta soils, seldom saturated during the growing season, are usually ready to absorb all the moisture that comes their way. Infiltration rate has been mentioned several times as an important factor affecting erosion. It should be realized that the rate at which water percolates downward through the soil will depend upon the soil layer or horizon which offers most resistance to water movement. We have many fields in Alberta where there is a hard compact layer of soil at a depth varying from a few inches to over a foot. This is particularly true of the soils classified as solonetzic. This layer is very

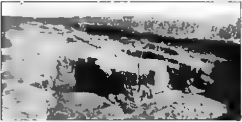


Figure 6. A major cause of the erosion damage in this field south of Sedgewick is the dense impervious subsoil characteristic of solonetzic soils.

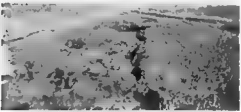


Figure 7. Compact fine-textured subsoils prevent rapid percolation of rainfall and cause excessive run-off and erosion as in this field.

impervious, and if the ground is level water will lie for days without draining away. Such impervious horizons cause a low infiltration rate and hence a high percentage of run-off. Heavy clay subsoils have a similar effect. Figure 6 illustrates what happens on solonetzic soils, large areas of which are found in the province. Notice how the topsoil overlying the dense impervious horizon has been stripped off. Figure 7 illustrates a common sight in fields where the soil is a heavy clay and infiltration slow.

Finally we might sum up all these characteristics of the soil in the word tilth. A soil is said to be in good tilth if it provides optimum growing conditions for crops. Such a soil is well aggregated and hence well aerated, it will permit rapid infiltration of rainfall, cover crops will grow rapidly and protect the soil surface.

PRECIPITATION STUDIES IN ALBERTA

Records of total precipitation have been kept at many widely scattered points in Alberta for many years. Experimental stations, grain companies, and weather stations of the Dominion Meteorological Service have collected data of this kind in at least a hundred different locations. The Lacombe Experimental Station has collected data since 1908, the Meteorological Stations in Medicine Hat, Calgary, Lethbridge and Edmonton since about 1890. The Meteorological Division of the Department of Transport issues a weekly weather summary giving the precipitation at 58 stations in Alberta's seventeen crop districts, many of them showing data for 30 years or more.

Annual Precipitation

Table 1 gives the average precipitation at these stations for each of the six summer months, the per cent of total annual precipitation falling in these six months, the total for the year, and the number of years in each case entering into the average. The maps, Plate I and II, show the distribution of precipitation throughout the province first during June and July, second during the whole year. They are based chiefly on the data in Table 1. Since half of the averages are based on periods of less than thirty years and since the collection of these data represents the efforts of a large number of persons, there is no doubt that the annual precipitation map is not as accurate as might be desired. Records of other weather stations have suggested for example considerable changes in the pattern that would have been suggested had the data for Dunvegan and Peace River Crossing alone been used. In other parts of the map broken isohyetal lines (lines joining points with equal annual precipitation) suggest doubtful locations of the lines. It will be

TABLE 1

Precipitation in Alberta During Six Summer Months and Total Annual Precipitation
(Dominion Meteorological Division Data)

	No. Yrs. Record	Precipitation in Summer Months						% of Total Annual Precipitation	Total Annual
		April	May	June	July	Aug.	Sept		
Bow River Area									
Bassano	20	1.22	2.16	1.78	2.06	1.32	1.35	72.9	13.57
Calgary	55	0.98	2.34	3.[illegible]4	2.5[illegible]	2.29	1.50	76.7	16.65
Cardston	23	1.27	2.80	3.43	1.81	1.79	2.16	69.1	19.33
Expanse Coulee	28	0.68	1.44	2.00	1.67	1.50	1.41	72.9	12.20
Foremost	15	1.53	1.88	2.81	1.6[illegible]	1.88	1.69		
Gleichen	35	1.28	1.77	2.35	2.08	1.70	1.04	73.5	13.98
High River	26	1.69	2.02	3.31	1.72	2.22	1.73	68.0	18.67
Lethbridge	30	1.20	1.85	2.67	1.60	1.48	1.51	68.7	15.01
Macleod	38	0.92	1.88	2.83	1.66	1.58	1.52	69.9	15.00
Medicine Hat	56	0.77	1.61	2.42	1.68	1.36	1.13	70.0	12.81
Pekisko	28	2.01	2.92	3.8[illegible]	2.05	2.60	2.35	70.8	22.42
Pincher Creek	35	1.54	2.67	3.29	2.28	2.05	1.95	68.9	20.01
Raymond	15	1.69	1.68	2.76	1.58	1.03	1.59	67.1	15.39
Strathmore	25	1.05	2.02	3.04	1.93	2.00	1.40	75.4	14.97
Rocky Mountains Area									
Banff	49	1.14	1.97	2.81	2.0[illegible]	2.21	1.65	61.5	19.[illegible]6
Lake Louise	21	1.2[illegible]	1.52	2.48	1.64	1.79	1.82	43.6	23.83
Red Deer River Area									
Alix	32	0.98	1.87	2.91	2.82	2.09	1.39	72.1	16.44
Hanna	16	1.17	1.72	2.90	2.56	.46	0.90	75.7	14.15
Hillsdown	34	1.10	1.75	3.75	2.27	1.99	1.50	72.5	17.06
Jenner	20	1.03	1.56	1.64	1.42	.22	1.23	68.7	12.15
Lacombe	32	1.07	1.96	3.35	2.62	2.30	1.60	75.9	17.00
Olds	25	1.30	2.13	3.02	2.37	2.77	1.60	72.7	18.43
Perbeck	25	0.80	1.88	3.15	2.05	2.06	1.63	79.7	14.51
Red Deer	35	1.17	2.67	3.92	3.16	2.88	2.29	78.5	20.63
Springdale	25	1.38	2.17	3.58	3.11	3.11	2.03	74.9	20.54
North Saskatchewan River Area									
Calmar	20	1.20	2.37	3.00	3.00	2.46	1.13	74.5	18.36
Camrose	15	1.2[illegible]	1.87	2.34	2.67	1.82	1.5[illegible]	73.6	15.57
Edmonton	55	0.88	1.55	3.06	3.32	2.35	1.33	73.6	17.38
Elk Point	29	0.86	1.49	2.87	2.57	1.80	1.22	73.1	14.79
Halkirk	21	0.77	1.92	3.22	2.80	3.34	1.52	80.1	15.69
Nordegg	24	1.32	2.09	3.64	3.56	2.85	1.88	73.0	21.02
Ranfurly	34	1.04	1.93	3.13	2.94	2.94	2.47	80.8	17.93
Rocky Mtn. House	22	1.6[illegible]	1.82	3.28	2.33	2.98	2.26	74.5	19.13
Sion	24	0.87	1.68	3.52	3.11	2.06	2.24	70.6	17.69
Viking	19	1.00	1.80	2.19	2.81	2.13	1.3[illegible]	74.8	15.01
Westina	25	0.74	1.38	2.4[illegible]	2.03	1.38	1.06	78.2	11.76
Wetaskiwin	33	0.68	1.80	3.18	2.63	2.26	1.50	73.2	16.73
Athabasca River Area									
Athabasca	2[illegible]	0.71	2.10	2.82	3.30	2.31	1.32	67.6	18.33
Campsie	26	0.87	2.00	3.20	3.62	2.54	1.48	73.6	18.63
Edson	22	0.98	1.52	3.15	3.21	2.97	1.63	72.2	18.64
Fort Chipewyan	55	0.70	0.8[illegible]	1.35	2.22	1.61	1.35	66.7	12.55
Fort McMurray	35	0.80	1.47	2.10	3.30	2.[illegible]8	2.01	67.0	17.71
Grouard	20	0.71	1.67	2.78	2.84	1.85	1.66	64.2	17.94
Jasper	22	0.69	1.05	1.45	1.73	1.69	1.35	60.9	13.06
Wabasca	20	0.65	1.97	2.63	3.07	2.37	1.64	75.6	16.58
Peace River Area									
Beaverlodge	31	.78	1.64	2.71	2.2[illegible]	1.81	1.71	59.8	17.19
Dunvegan	27	.60	.91	2.08	1.95	1.18	1.65	59.6	14.01
Fort Vermilion	30	.64	1.12	1.82	2.05	1.74	1.34	71.8	12.10
Peace R. Crossing	42	.44	1.28	2.58	1.82	1.36	1.33	68.2	12.90
Beaver River Area									
Iron R.	13	1.00	1.51	2.74	2.49	1.81	1.25	76.1	14.19

observed that only a very small portion of Alberta's cultivated area receives more than twenty inches of precipitation per year as an average while large portions receive less than eighteen inches. The dark brown and thin black soil zones, our most important wheat-growing area, averages from fourteen to little more than fifteen and a half inches, the Peace River area about sixteen, while our black soil zone averages about seventeen. Compare these figures with those of Missouri, Oklahoma or Pennsylvania, where water erosion is a serious problem, or Ontario where soil conservation is receiving much attention. In Missouri the lowest rainfall in the state averages 32 inches per year while the highest is 50 inches, Oklahoma's precipitation varies from 34 to 50. It is obvious that Alberta's relatively low annual rainfall makes erosion much less a problem than in the states mentioned, even though the proportion of rain falling in the summer months is 15 to 20 per cent higher here in Alberta. For example, we may compare Edmonton's summer rainfall (April 1 to September 30) of 12.8 inches with the more than 25 inches that half the state of Missouri receives in the same period. More than half the state of Pennsylvania receives over 22 inches in the summer period, and in Oklahoma the figure is 23 inches. Ontario's rainfall in the crop growing area varies from 30 to 35 inches per year, and approximately half of it falls during the summer months. Toronto, for example, receives 16.6 inches, April to September, while Edmonton receives 12.8 inches. It is important that we in Alberta recognize these differences and adopt control measures adapted to our own conditions. There is a tendency to adopt the same methods of controlling erosion that are used in other parts of the world where the risk of erosion is much greater.

Records of 24-hour Rainfall

Let us now turn to a consideration of rainfall intensity in Alberta and compare conditions here with those elsewhere. First, we may consider total rainfall in 24-hour periods as an indication of intensity. June, July and August are the months of greatest rainfall over large portions of the province, as shown in Table 1. It is interesting to note in Table 1 that only in the Athabaska River area is the average monthly rainfall greatest in July. In all other parts of the province June rainfall is usually the greater. Edmonton and a few other points are exceptions to this generalization. July and August are the months of thunderstorms and heavy showers. What is a heavy rainfall by Alberta standards? Records of the seventy-odd Alberta weather stations reporting in the Monthly Record of the Meteorological Division, Department of Transport, are summarized in Table 2 to answer this question. The heaviest rainfall during

TABLE 2

Number of Weather Stations in Alberta with Heaviest 24-hour Rainfall during June, July and August in Category Shown

(NOTE The first figure in the table 10, for example, means that in June, 1935, there were 10 stations where the heaviest 24-hour rainfall during the month was 0.50 inches or less)

Ins. of Precipitation in Heaviest 24-hr. Rainfall during Month	0.01–0.50	0.51–1.00	1.01–1.50	1.51–2.00	2.01–2.50	2.51–3.00	3.01–3.50	3.51–4.00	4.01–4.50	4.51–5.00
June 1935	10	24	22	3	2	0	1			
" '36	13	38	9	1	1					
" '39	13	35	15	6	1					
" '40	29	33	8	1						
" '41	14	27	16	9	3					
" '42	8	21	29	12	4	2	1	1		
" '43	23	24	17	7						
" '44	9	27	12	8	6	1	2	1	1	
" '45	18	37	12	3						
" '46	10	29	21	6	3	0	0	2		
July 1935	12	23	21	5	1	0	1			
" '36	32	22	4	4						
" '37	13	23	9	12	1	3	2	0	2	1
" '39	33	24	4	6	5					
" '41	32	30	7	3	1					
" '42	14	22	22	13	7	0	0	1		
" '43	39	32	8	2						
" '44	28	30	11	11	4	1				
" '45	32	26	13	11	1	0	1			
" '46	31	29	14	4	1	0	1			
Aug. 1936	23	29	7	2						
" '37	18	25	14	5	1	0	1			
" '39	56	14	1							
" '40	80	7	2							
" '41	16	29	16	5	4					
" '42	16	43	9	3	0	1				
" '43	29	29	13							
" '44	28	33	8	1	1					
" '45	34	20	5	6	3	2	1			
" '46	15	32	14	5	0	1				
Total No.	702	819	366	153	50	13	11	5	3	1
Per cent of total	33.0	38.6	17.2	7.2	2.4	.6	.5	.2	.1	.05

the 10-year periods used was in July 1937, at the Thorsby weather station. During a 24-hour period 4.83 inches of precipitation were recorded. At Edmonton, the heaviest 24-hour rainfall ever recorded (up to November, 1949) was 4.17 inches on July 15, 1937. This record covers almost 60 years. Table 2 shows, however, that two other stations since 1935 have had over 4.00 inches in one day. These were Thorsby with 4.16 inches in one day in June, 1944, and Nordegg with 4.10 inches in one day in July, 1937. The five stations showing heavy 24-hour rainfalls of 3.51 to 4.00 inches are:

Strathmore	June, 1942	3.58″
Calmar	June, 1944	3.66″
High River	June, 1946	3.59″
Macleod	June, 1946	3.82″
Ranfurly	July, 1942	3.52″

Table 2 shows that 71.6% of the heaviest storms gave us 1.00 inch or less, and 88.8% 1.50 inches or less. It would seem reasonable to conclude on the basis of these data that only once in ten years can any station in Alberta expect a 24-hour rainfall of as much as five inches. How does this compare with records elsewhere? The United States Department of Agriculture Yearbook for 1941 gives some interesting information. In New Jersey heavy 24-hour falls of 7 or 8 inches are occasionally recorded, in Kentucky twenty-four hour precipitation in heavy rains is frequently 3 or 4, occasionally 8 inches, and as much as 10 inches in some extremely heavy falls, in Missouri, more than 10 inches have been recorded within 24 consecutive hours; in Oklahoma, 24-hour falls of more than 10 inches are on record at a number of stations in scattered localities, in Louisiana, thunderstorms have in a few instances brought rainfalls exceeding 14 inches in 24 hours. The record for the United States is held by Smyrna, Florida, where in October 1924, 23.22 inches of rain fell in 24 hours. It has been reported that in one locality in India in October 1949, the rainfall during a twenty-four hour period was 27 inches, and the world's record is held by Baguio in the Philippines, where a 46-inch fall was reported on July 15, 1911. The point may be emphasized again, therefore, that Alberta's water erosion risks are not as heavy as in many parts of the world.

Records of 1-hour Rainfall

The maximum one hour rainfall recorded in heavy showers is given in Table 3 for the years 1914-1919, 1931-1937, and 1949. The storm of July 16, 1949, brought 1.86 inches during the hour of greatest precipitation and is the record so far as the data available are concerned. Notice that in this 14-year period at Edmonton only four storms delivered more than one inch of rainfall in any one hour. These storms are mild by comparison with records of many United States weather stations for the period 1899-1938. While the maximum precipitation in any one hour reached only 2 inches in Montana (comparable to our Edmonton figure of 1.86 mentioned above), 24 of the states had areas reporting over 3 inches in one hour, 8 states with areas reporting over 4 inches, and Texas and North Carolina both had areas reporting over 5 inches. Referring back to Table 3, notice that most of our storms give us less than half an inch in one hour, and only once in about fifteen years can we expect two inches in one hour.

TABLE 3

Classification of Rains on Basis of One-hour Intensity at Edmonton During Six Months for the Years 1914-1919, 1931-1937 and 1949

Month	Intensity in inches per hour for 1-hour period									
	0-.19	.20-.39	.40-.59	.60-.79	.80-.99	1.00-1.19	1.20-1.39	1.40-1.59	1.60-1.79	1.80-1.99
April	8	2								
May	10	4	2	1	0	1				
June	5	5	5	1	0	1	0	0	0	1
July	1	6	0	2	0	0	0	1		
August	3	1	1							
September	11									
Total	38	20	8	3	0	2	0	1	0	1
Per cent of total	52.0	27.4	11.0	4.1		3.5		1.3		1.3

Intensity of Rainfall

Turning now to intensity of rainfall, we might again define the term as the rate at which rain falls expressed in terms of inches per hour. This characteristic of a rainfall determines to a large extent whether there will be erosion or not. While there is a large amount of data available on total precipitation throughout the province, there is very little on intensity. The City of Edmonton has been recording intensity data for heavy rains since 1914 except for the period 1920 to 1924. The Dominion Meteorological station in Edmonton has records dating from 1914 except for the years 1920 to 1930 and 1938 to 1942. The Department of Soils set up an intensity recording apparatus early in 1950 at St. Albert and so has data for one year only.

At all three locations mentioned above the apparatus for recording intensity consists of a large collecting funnel, 12 inches in diameter or a square funnel with an equivalent area, draining into a small bucket that tips when 0.01 inches of rainfall has been collected. The bucket on tipping momentarily closes an electrical circuit which by a suitable system of magnets, ratchet, levers, and pen records the event on a graph paper mounted on a drum turning at constant speed. An examination of the graph permits one to determine the number of hundredths of an inch of rainfall during any given period, for example five minutes, and from this the maximum intensity during a given storm can be calculated. Another type of intensity gauge collects the precipitation in a pail mounted on a scale. The total weight of pail and water is recorded on a graph paper and the rate of increase in weight can be expressed in terms of rainfall intensity.

In Figure 8 a portion of the 1950 records at St. Alberta is reproduced, showing how a shower on the afternoon of August 6th was

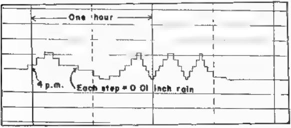


Figure 8.—A portion of an intensity graph showing how the rate of rainfall is recorded at the Soils Department erosion plots, St. Albert

recorded. The diagram is a full-size reproduction of the graph. It will be seen that at no time did the rain fall at a rate exceeding half an inch per hour. During the fifteen minute period when it was most intense the rate was 0.40 inches per hour, a relatively light rain involving very little risk of erosion or run-off.

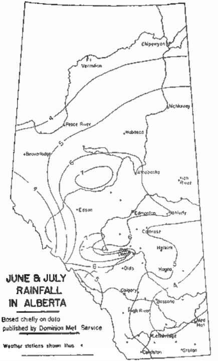
A summary of intensities of heavy rains recorded by the Dominion Meteorological Station at Edmonton is given in Table 4. Only those storms are included whose maximum rainfall during a five minute period reached 0.08 inches, that is an intensity of 0.96 inches per hour. The summary covers the year 1914-1919, 1931-1937 and 1944-1949.

TABLE 4

Classification of Heavy Rains on Basis of Five-Minute Intensity at Edmonton During Six Months for the Year 1914-1919, 1931-1937, and 1944-1949

(Note. This table includes only those rains with a maximum five-minute intensity of 0.96 inches per hour or more.)

Month	Intensity in inches per hour for 5-minute periods							
	0.96–1.45	1.46–1.95	1.96–2.45	2.46–2.95	2.96–3.45	3.46–3.95	3.96–4.45	4.46–4.95
April	0							
May	1							
June	6	5	1	0	1	0	0	1
July	10	3	1	1	1	1	2	
August	9	3	0	0	2	2		
September	0	0	1					
Total	26	11	3	1	4	3	2	1



Total rainfall in June and July in inches throughout Alberta. This map is based on the data appearing in Table 1 and published by the Meteorological Division, Department of Transport, in Volume 1 of "Climatic Summaries"

PLATE II.

ANNUAL PRECIPITATION IN ALBERTA

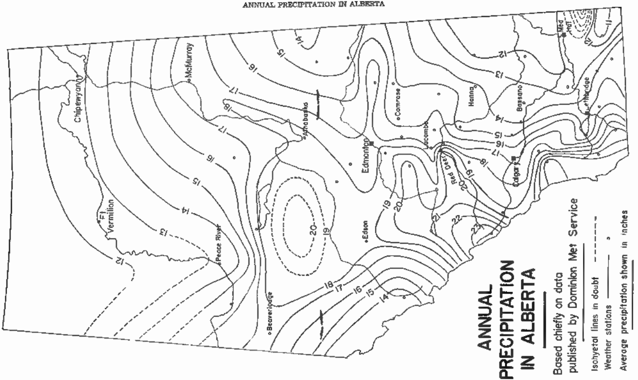


PLATE III.

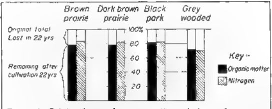


Figure 1 Relative losses of organic matter and nitrogen from upper 6 inches of soil in different soil zones on cultivation for 22 years

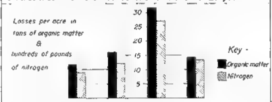


Figure 2 Average losses of organic matter and nitrogen from upper 12 inches of soil on cultivation for 22 years

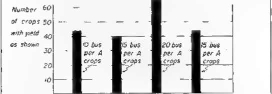


Figure 3 Theoretical number of crops of wheat that could be grown from nitrogen lost in 22 years

As long time residents would expect, the record shows June, July and August with the largest number of rainfalls of high intensity, and July probably leading the field. The storm with the highest intensity occurred in June, 1918, when in one five-minute period 0.41 inches of rain fell. This would be at a rate of 4.92 inches per hour. Compare with this figure the storm of July 16, 1949, in Edmonton when the maximum fall in a 5-minute period was 0.34 inches, a rate of 4.08 inches per hour.

Let us turn to some United States data on intensity. At the State College of Pennsylvania the average rainfall is 38.8 inches, and rainfalls of high intensity can cause considerable erosion damage. Many years of accumulated data show that once every two years a storm can be expected which will have a maximum 5-minute intensity of 4.80 inches per hour, which is almost equal to the most severe storm ever recorded at Edmonton and mentioned above. Once every ten years a storm can be expected at that station with a maximum 5-minute intensity of 6.12 inches per hour, and once every 50 years a storm with 7.20 inches per hour as maximum intensity. During the period 1936-1945 two gauges one mile apart recorded intensity at the College Experiment Station. One gauge recorded 4 storms in that time exceeding 4.80, and 1 storm exceeding 5.52 inches per hour as maximum intensities during 5-minute periods, the other gauge recorded 17 storms exceeding 4.80, 9 exceeding 5.52, 4 exceeding 6.12, 2 exceeding 6.84, and 1 exceeding 7.20 inches per hour intensity. The wide variation between these two stations, although they were only a mile apart, emphasizes the fact that heavy showers in summer fall on localized areas. The variation casts considerable doubt on any conclusions we might make with regard to rainfall intensity using as our basis the data from only one or even two recording instruments here in Alberta.

It would seem safe to conclude that water erosion risks in Alberta are small compared to elsewhere. But it is in this lack of serious danger that our problem lies. Too many of us are perhaps inclined to disregard the erosion problem altogether, and it is this lethargy which must be overcome.

Although our intense storms may be few in number and not severe by some standards, they are serious enough to cause extensive damage to our crops and fields. Figures 9, 10 and 11 are photographs that were all taken in 1950.

Figure 9.—A steep slope in crop near St. Albert badly cut by water erosion in an intense July storm.

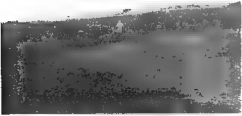


Figure 10.—Erosion east of Penhold from a heavy June rain.

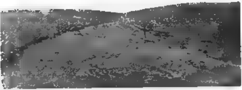


Figure 11.—Tons of topsoil were washed off this sandy hillside south of Edmonton in a single summer storm in 1950.

EROSION PLOT STUDIES

The St. Albert Erosion Plots

The Soils Department of the University established erosion plots on the Atkinson brothers' farm at St. Albert in 1949. See Figures 12, 13 and 14.

A corner of a virgin pasture with a fairly uniform 12 per cent slope was chosen as the site for the plots. Eight plots were laid out, each 6 feet wide and 72.6 feet long and one-hundredth of an acre in area. Plots were separated from one another by 1 x 12 inch planks placed on edge and sunk to a depth of 8 inches, the object of these being the control of the run-off from the plots. At the foot of each plot a trough and tub were placed to receive run-off and eroded soil. One of the eight plots was left with its virgin sod undisturbed; the remainder were broken, worked and crops planted in 1949. Two plots were allocated to a wheat-fallow sequence while the remaining five plots were devoted to a five-year rotation of wheat-oats-barley-hay-hay. A rain gauge was set up in 1949 and in 1950 an intensity gauge was also established at the plots. The object of the plots is to correlate precipitation studies with run-off and soil losses under the different cropping systems and plant covers. It may be noted that this type of experiment has been conducted for many years at several of the Soil Conservation Stations in the United States, and similar projects may also be found in Eastern Canada. Many of these are of a much more elaborate plan involving different per cent slopes, different lengths of slope, different cropping practices, and more accurate and extensive equipment. By means of such projects many of the principles of erosion such as effect of slope and crop cover have already been established. Nevertheless, it is hoped that this simple project at St. Albert will permit a verification under at least one set of Alberta conditions.

Erosion Plot Data for 1949

Only two plots were equipped to measure run-off and soil loss in 1949—the virgin sod plot and the fallow plot. The fallow, being a newly broken sod was of course not typical of the general run of fallow fields. However an examination of the data collected during the year is probably worth while, and by examining Table 5 a number of observations may be made. There was only a small proportion of the storms intense enough to cause run-off and erosion, a fact which reflects our earlier observation that Alberta's summer storms are low in intensity compared to those elsewhere. The per cent of rainfall lost by run-off was low in the few storms

Figure 12.—View of erosion plots at St. Albert showing arrangements for collecting run-off and eroded soil.

Figure 13.—View of the plots in July, 1950, showing the eight plots in order from the right—virgin sod, wheat, fallow, oats, barley, hay, hay and wheat.

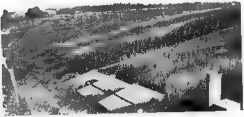


Figure 14.—General overall view of the plots showing the gauge for recording intensity in the foreground.

Water and Soil Losses at Erosion Plots, St. Albert. 1949

Date of Storm		Total Precipitation in inches	Plot 1 Virgin Sod		Plot 2 Fallow	
			% Rain lost by run-off	Soil loss in lbs. per acre	% Rain lost by run-off	Soil loss in lbs per acre
June	28	0.28	0.01		0	
"	29	0.17	0.40	Trace	0.20	Trace
July	3	0.06	0		0	
	5	0.14	0		0	
	7	0.03	0		0	
	12	0.30	0		0	
	16	1.97	10*	10	15*	700
	19	0.23	0		0	
"	20	0.11	0		0	
"	22	0.01	0		0	
"	25	0.38	0		0	
"	26	0.58	1.2	4.5	4.8	45.0
"	29	0.56	1.3	9.0	2.8	14.0
Aug.	9	0.40	0		0	
"	10	0.05	0		0	
"	13	0.40	5.0	25.0	19.0	244.0
"	22	0.38	0		0	
"	23	0.41	0		0	
Sept.	10	0.30	0		0	
"	20	0.41	0		0	

*Estimated.

where there was a loss, the greatest loss being less than 20 per cent. The greatest amount of soil lost in any one storm was about 700 pounds per acre from the fallow plot. Total soil lost by erosion during the season from plot 2 was about 1000 pounds per acre. Since an acre of soil to plow depth weighs approximately 2,000,000 pounds, it appears that at the 1949 rate of soil loss from plot 2 it would take many years to erode away the top soil. No doubt soil losses from the plots will increase as the large reserves of organic matter become depleted through cropping. Another point worth noticing in Table 5 is the effect of intensity on run-off and erosion. The storms on August 9, 13, 23 and September 20 all delivered the same amount of rain, but in only one of the storms was the rate of fall too rapid for the soil to absorb the water.

Erosion Plot Data for 1950

In 1950 all eight plots were equipped to measure run-off, and in addition the intensity of the rainfall in the various storms was recorded. Data for 1950 are shown in Table 6. Again we see, as in 1949, that only a few of the storms caused run-off. The data for June 6 are surprising. The plots had only recently been worked over, and while the fallow plot was loose and roughened by the cultivation received, the wheat plot was compacted and smoothed as a result of seeding operations. Hence there was considerable run-off from Plot 2, the wheat plot, but none from Plot 3, the fallow

plot, in spite of the heavy rain. The data for the August 14-15 storm are also interesting. While there were soil and water losses on all other plots there was practically none from the oats plot. This was no doubt due to an extremely heavy stand on this plot. See Figure 13, which shows the heavy stand of oats in midsummer. The most serious loss of rainfall was from the fallow plot on August 14 and 15 when over 3 per cent of the precipitation was lost through run-off, but compare this with 15 erosive July rains in five successive years at the erosion station in Pennsylvania where the average run-off from fallow plots was 37.79 per cent. The heaviest loss of soil at the St. Albert plots in 1950 was from the fallow plot where the loss for the year totalled less than half a ton per acre. Contrasting with this are the soil losses in the 15 erosive rains in Pennsylvania above. Every one of the 15 washed off over half a ton of soil per acre, 10 of them over one ton, 8 over 2.50 tons, 5 over 5.00 tons, 1 over 7.50 tons, and the worst of the storms eroded over 10.00 tons per acre.

TABLE 5

Per Cent Rainfall and Pounds of Soil Lost Per Acre, at Erosion Plots, St. Albert, 1950

Date of Rain	Pptn.	Plot 1 Sod	Plot 2 Wheat	Plot 3 Fallow	Plot 4 Oats	Plot 5 Barley	Plot 6 Hay	Plot 7 Hay	Plot 8 Wheat
May 19	0.37	0	0	0	0	0	0	0	0
" 31	0.11	0	0	0	0	0	0	0	0
June 1	0.02	0	0	0	0	0	0	0	0
" 4	0.17	0	0	0	0	0	0	0	0
" 6	1.41	0.08*	0.21	0	0.05	0.16	0.31	0.21	0.31
		no soil	T†		T	T	T	T	T
" 20	0.01	0	0	0	0	0	0	0	0
" 23	0.06	0	0	0	0	0	0	0	0
" 26	0.19	0	0	0	0	0	0	0	0
July 3	0.10	0	0	0	0	0	0	0	0
" 7	0.08	0	0	0	0	0	0	0	0
" 10	0.10	0	0	0	0	0	0	0	0
" 11	1.38	0.36	0.40	0.32	0.12	0.12	0	0.18	0.12
		no soil	T	T	T	T	T	T	T
" 14	1.06	0.10	0.15	0.05	0.10	0.02	0.15	0.13	0.17
		no soil	T	T	T	T	T	T	T
" 16	0.39	0	0	0	0	0	0	0	0
" 18	0.12	0	0	0	0	0	0	0	0
" 29	0.35	0.05	0.20	0.10	0.10	0.10	0.10	0.10	0.10
		no soil	87	99	112	97	75	193	67
Aug. 3	0.18	0	0	0	0	0	0	0	0
" 8	0.41	0	T	0	0	0	0	0	0
" 10	0.15	0	0	0	0	0	0	0	0
" 11	0.05	0	0	0	0	0	0	0	0
" 14 & 15	1.51	0.29	1.68	3.16	0.04			0.24	.21
		5	20	708	T			20	4
" 29	0.26	0	0	0	0	0	0	0	0

*The upper figure in each case is per cent rainfall lost by run-off.

†T=trace of soil.

A field adjacent to the St. Albert erosion plots was fallowed in 1950 as a result of the failure of a hay crop in the dry spring. Through an oversight the main watercourse leading down through the field had been cultivated too instead of leaving the stubble and small stand of hay for protection. The consequences appear on August 15 when every ounce of top soil in a channel half a rod wide and forty rods long (about 125 tons of soil—20 truck loads of top soil for which gardeners in the city would pay $200.00) was washed away and deposited in a pasture. The storm causing this damage was heavy and intense, and the landowner maintained the erosion to be the worst he had seen on the farm. The actual maximum 5-minute intensity was 2.88 inches per hour. While this is not high, the intense rain continued for twenty minutes during which 0.85 inches of rain fell, and it was therefore the total rainfall as well as the intensity of the storm that led to the damage. In a nearby barley field was a grassed-in waterway and there was no serious washing and no gullying whatsoever.

ANALYSES OF SOILS SUBJECT TO EROSION

Methods

As mentioned earlier, the Soils Department has been collecting for several years soil samples from slopes where virgin and cultivated soil lay side by side. The object was to determine the extent to which erosion depleted the supplies of organic matter and plant nutrients, particularly nitrogen and phosphorus. Losses of nitrogen are directly proportional to losses of organic matter. Each sample was a composite from at least ten sites, and duplicate samples were collected. Samples of both the topsoil (0"-6") and subsoil (6"-12") were taken. The steep portion of the slope thus provided eight samples, four of virgin soil and four of cultivated soil, and the more level upper part of the slope provided eight more samples. In addition a sample of the outwash was collected when possible. Six slopes, at Edmonton, Drumheller, Innisfree, Clandonald, Swalwell, and Girouxville were sampled in this way. Laboratory analyses for nitrogen and phosphorus followed.

Effect on Nitrogen and Phosphorus Content

First let us look at the results of the analyses for total nitrogen on these samples. The data are summarized in Table 7, which shows the actual per cent nitrogen in the various samples, and Table 8, which shows the change in nitrogen content of the soils following cultivation. The changes have been caused undoubtedly by two factors, namely a decrease in organic matter content associated with cultivation and cropping and a loss of organic matter

as a result of erosion. The Department of Soils, in co-operation with the Experimental Farms Service, Dominion Department of Agriculture, has made extensive studies of the former, reporting results in *Scientific Agriculture* under the heading "Effects of Cultivation and Cropping on the Chemical Composition of Some Western Canada Prairie Soils". A resumé of a series of reports is given in this bulletin starting on page 28. We are primarily interested here in comparing the figures for the slopes with those for the topland

TABLE 7

Per Cent Total Nitrogen in Virgin and Cultivated Soils Subject to Erosion

Location and Years Cultivated	Source of Sample	Virgin Depth in inches 0–6	Virgin Depth in inches 6–12	Cultivated Depth in inches 0–6	Cultivated Depth in inches 6–12
West of Edmonton 1-53-25-W4 8 years	Almost level top land Steep part of slope Outwash	.924* .815	.212 .238	.616 .513 .205	.177 .230
East of Carbon 15-29-21-W4 23 years	Almost level top land Steep part of slope Outwash	.964 .676	.583 .376	.913 .632 .897	.569 .398
North of Carbon 9-30-23-W4 28 years	Almost level top land Steep part of slope Outwash	1.180 1.300	1.040 .830	.582 .526 .797	.352 .346
North of Vermilion 17-52-6-W4 20 years	Almost level top land Steep part of slope (a 30% slope)	.635 .75	.276 .283	.372 .468	.302 .347
Near Innisfree 2-51-11-W4 20-22 years	Almost level top land Steep part of slope	.550 .384	.198 .179	.283 .239	.115 .127
Near Girouxville 34-76-22-W5 10 years	Steep part of slope	0″-8″ only 0.284		0″-8″ only 0.306	

*Each figure in the table is an average of two nitrogen determinations, there being two composite samples in each case.

TABLE 8

Per Cent Change in Nitrogen Content as a Result of Cultivation and Erosion

Location	Depth in inches 0-6 Topland	Depth in inches 0-6 Slope	Depth in inches 0-12 Topland	Depth in inches 0-12 Slope
Edmonton	—33.4%	—37.1%	—30.3%	—29.6%
Carbon	5.3	6.5	— 3.5	— 2.1
Carbon	—50.7	—59.6	—58.0	—59.0
Vermilion	—41.5	—37.5	—26.0	—20.9
Innisfree	—48.6	—37.8	—46.8	—34.8
Girouxville		+ 7.8		

Table 8 shows no consistent trend that would indicate a serious loss of nitrogen due to erosion on the slopes. With respect to phosphorus, only some of the samples were analyzed for total phosphorus content. The phosphorus data obtained are given in Table 9. Again no consistent trends were indicated.

TABLE 9

Per Cent Total Phosphorus in Virgin and Cultivated Top Soils Subject to Erosion

Legal Location	Source of Sample	Virgin	Cultivated	Change due to Cultivation and Erosion
1-53-25-W4	Topland	.064%	.070%	+ .006%
	Slope	.066	.060	— .006
15-29-21-W4	Topland	.060	.069	+ .009
	Slope	.070	.069	.001
8-30-23-W4	Topland	.081	.063	— .018
	Slope	.079	.046	— .033

Further Analyses 1950

In an effort to gather further evidence of the results of erosion fourteen more slopes were sampled in 1950 in a similar manner to that described above. Samples of outwash and subsurface (6"-12") samples of top land were not collected, however. Analyses for total nitrogen were made in duplicate on the twelve samples from each field. The data obtained are summarized in Table 10 and the per cent changes in nitrogen content as a result of cultivation and erosion are shown in Table 11. As in Tables 7 and 8 above, we see large variations and again there seems to be no consistent trend. The Namao sample collected on a 30 per cent slope showed very definitely the effects of erosion. In six of the other locations the data suggest some erosion losses, but in the remaining five cases the nitrogen level had decreased more on the topland than on the slope.

These data therefore while adding emphasis to the fact that the organic matter in virgin soils decomposes and disappears rapidly when the soil is cultivated, with a consequent decrease in total nitrogen content, indicate that the deterioration of our Western Canada soils is due rather to cultivation and cropping than to water erosion. Steep cultivated slopes would be an exception to this, water erosion being a more important factor in the deterioration of such a soil. These conclusions are in line with observations already made concerning Alberta's rainfall.

It is of course true that the soils sampled for these studies are not representative of all Alberta soils, but it may be noted that they cover a considerable range—soils from Dark Brown, Thin Black, Black, and Transition Zones; soils from light and heavy rainfall areas; soils varying in texture from clays to loams, silt loams, and sandy loams.

TABLE 10

Per Cent Total Nitrogen in Virgin and Cultivated Soils Subject to Erosion

Location and Field		Slope	Virgin: Depth in inches 0-6	Virgin: Depth in inches 6-12	Cultivated: Depth in inches 0-6	Cultivated: Depth in inches 6-12
St. Albert	(A)	15%	.459	.345	.508	.346
		3	.537		.444	
"	(B)	8	.892	.367	.615	.389
Namao	(C)	30	.485	.259	.221	.188
		3	.460		.431	
St. Albert	(D)	15	.351	.169	.282	.114
		3	.332		.182	
"	(E)	18	.545	.450	.323	.222
		4	.559		.347	
Bittern L.	(F)	12	.431	.225	.238	.215
Ervick	(G)	13	.625	.413	.437	.219
		2	.524		.398	
Dorenlee	(H)	12	.614	.524	.553	.449
		1	.458		.475	
Castor	(K)	15	.287	.282	.250	.233
		0	.256		.288	
Morrin	(L)	8	.352		.277	
		1	.337		.264	
Drumheller	(M)	17	.381	.374	.338	.266
		2	.398		.337	
"	(N)	13	.414	.332	.394	.345
		1	.415		.378	
Three Hills	(O)	12	.326	.232	.263	.185
		2	.352		.291	
Huxley	(P)	14	.557	.390	.423	.375
		1	.443		.408	

TABLE 11

Per Cent Change in Nitrogen Content as a Result of Cultivation and Erosion

Location		Depth in inches 0-6: Topland	Depth in inches 0-6: Slope	Depth in ins. 0-12: Slope
St. Albert	A	—20.3%	+10.7%	+ 6.2%
	B		11.1	5.1
Namao	C	6.3	-54.5	-43.7
St. Albert	D	—45.2	—19.7	-20.8
	E	—36.0	—40.8	—45.3
Bittern L.	F		—44.8	—31.2
Ervick	G	-24.1	-30.1	-36.8
Dorenlee	H	+ 3.7	9.9	—11.9
Castor	K	+ 12.5	—12.8	—15.1
Morrin	L	21.7	—21.3	
Drumheller	M	15.3	11.3	—19.9
"	N	— 8.9	— 4.8	— 1.1
Three Hills	O	—17.3	19.3	-19.7
Huxley	P	— 7.8	—24.1	—15.6

Comparative Value of Topsoil and Subsoil.

In connection with soil survey work many samples of Alberta's soils have been analyzed to a depth of four feet and it is possible to estimate therefore the value of the nutrients present in any given soil. Using the 1950 price of commonly used commercial fertilizers as a basis, nitrogen is found to be worth 13 cents a pound and phosphorus 13.7 cents. Now with these figures the value of the total nitrogen and phosphorus in an acre of soil to any desired depth can be calculated. Some calculations have been made for typical soils to a depth of four feet and are illustrated in Figure 15. The amount of both nitrogen and phosphorus decreases with depth but the decrease in the case of nitrogen is much more pronounced, particularly in the wooded soils and in the less fertile dark brown soils. In all four soils the seriousness of losing the top six inches of soil is apparent, particularly with respect to nitrogen. The nitrogen content of a soil is very closely correlated with the organic matter content, a dominating factor in soil productivity, hence losses of nitrogen mean not only a diminishing supply of this important nutrient but also impaired physical condition, water holding capacity, etc., resulting from the loss of the organic matter containing the nitrogen. The object of controlling water erosion is simply therefore the protection of these few valuable inches of topsoil.

EFFECTS OF CULTIVATION AND CROPPING ON CHEMICAL COMPOSITION OF SOILS WHEN EROSION IS NOT VERY OBVIOUS

An extensive investigation was started in 1936 and carried on for a number of years by the Department of Soils of the University of Alberta in co-operation with the Dominion Department of Agriculture, Experimental Farms Service, P.F.R.A. to determine by chemical analysis of many cropped and virgin soils what effects the present methods of farming have had on the organic matter of the soil, and on some total and available or easily soluble plant foods. Samples were collected in Saskatchewan and Manitoba as well as in Alberta.

Comparatively few actual determinations of the extent of the losses of soil organic matter in the Prairie Provinces of Canada had been made prior to the initiation of this investigation, although it is recognized that soil organic matter is the main natural source of available plant food, that it increases the moisture holding capacity of soils, reduces or prevents erosion by wind or water (if fibrous) and otherwise improves the physical properties of soils.

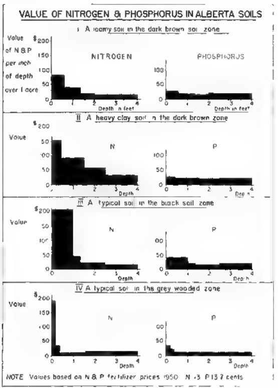


Figure 15.—Bar graphs showing value of nitrogen and phosphorus in some Alberta soils. See text, page 27

Although this particular project was chiefly concerned with losses from cultivated soil due to decomposition of organic matter, it is quite likely that erosion by wind and water plays a part in soil deterioration under cultivation even when the effects are not readily observable.

Methods of Sampling

Samples from approximately 100 locations, representing about 100 comparisons of virgin and cultivated soil, were collected from various points representative of the main cultivated soil zones in Alberta Saskatchewan and Manitoba

Duplicate composite samples of relatively old cultivated and nearby virgin soil were obtained at each location Also in some cases similar samples of more recently broken fields and corresponding virgin soils were obtained at or near the same location, in order to study rates of loss.

Results of Analyses

Under the prevailing grain and fallow system of farming in a period averaging 22 years the losses in percentage of organic matter from the surface 6 inches of brown, dark brown, and black soils were much alike on the average and amounted to about 20 per cent of the original content The losses in percentage of original nitrogen from the surface 6 inches of brown, dark brown, and black soils were also much alike on the average, and amounted to about 18 per cent of the original content However the losses in percentage of original organic matter and nitrogen content from the surface 6 inches were greater in the case of the grey wooded soils, amounting on the average to about 30 per cent of the original content These losses are shown graphically in Plate III, Figure 1. The greater percentage losses from the grey wooded soils may be due to the fact that the original soil organic matter consists in large measure of forest litter which is less decomposed (as indicated by a high carbon to nitrogen ratio), and therefore more readily decomposable when plowed down than the soil organic matter of the other zones.

Although the percentage losses were similar in the brown, dark brown and black soil zones, the total losses of organic matter and nitrogen increased with increase in original organic matter content in all zones (see Plate III, Fig 2) as might be expected under conditions favorable to decomposition provided by cultivation.

Organic matter is the main natural source of plant nutrients in the soil Plant nutrients such as nitrates, phosphates and sulphates are produced by decomposition of organic matter in soils. Nitrogen

is required in larger quantities than any other element taken up by ordinary non-legume plants. Although the losses of organic matter and nitrogen are evidently large, as shown in Fig. 2, it is difficult to realize their importance in terms of crop production. The losses of nitrogen are therefore expressed in terms of number of crops of wheat that could theoretically be produced from the nitrogen, assuming that the other necessary elements are present and that for every 10 bushels of crop produced per acre 20 pounds of nitrogen would be required (see Plate III, Fig. 3). On this basis it is obvious that a great part of the large quantity of nitrogen lost could not have been taken up by the crops grown on these soils during a period of 22 years under a grain and fallow system of farming. In fact, it has been estimated that on the average one-third to one-half, approximately, of the nitrogen lost from the surface layer of cultivated soil in the brown, dark brown, black and grey soil zones was absorbed by the crops grown on the soils. The large proportion of unaccounted for nitrogen may have been lost in various ways. It is quite likely that erosion by wind and water often plays a part in soil deterioration under cultivation even when their effects are not readily observable, and that this is especially the case where a grain and fallow system is followed.

Evidently the losses of organic matter and nitrogen are greatest after the land is first broken, and tend to decrease in later years where the land is not obviously eroded. The average annual loss of organic matter from the older cultivated fields (cultivated on the average for 28.5 years) was approximately half that of the newer cultivated fields (cultivated on the average for 9.2 years), and the average annual loss of nitrogen from the older cultivated fields was less than two-thirds that of the new fields. Thus there is a tendency to reach an equilibrium point, even under a grain and fallow system, at which losses caused by decomposition, crop absorption, and other factors, are balanced by gains in organic matter from plant growth, and gains in nitrogen due to non-symbiotic nitrogen fixation. However, it seems fairly certain that soil fertility would be seriously impaired at this point.

Maintenance of Organic Matter and Fibre

In the moister regions of Alberta both grasses and legumes may be grown in the rotations in order to guard against serious impairment of the soil's physical condition, organic matter content, and fertility. These should be supplemented by the use of barnyard manure where available, and by the use of commercial fertilizers where profitable. Where the threat of erosion is serious other recommended measures of control will be required. Serious losses

of organic matter and fibre and impairment of physical condition, in the drier regions of Alberta, may be guarded against by growing grasses in rotation with grain crops, in addition to maintaining a trash cover of stubble and straw on summerfallowed land (and other recommended erosion control measures). It is often impractical to grow a legume in rotation with grain crops in the drier regions of the prairie provinces, but it is commonly practical in such regions to seed the land down to a drought resistant grass for a few years, periodically, and thus restore fibre and organic matter to the soil.

CONTROL METHODS FOR ALBERTA

From what has been said above with respect to precipitation, soil erosion plot studies, and soil analyses it is clear that water erosion is not as serious a problem in Alberta as it is in regions with heavier rainfall, but because of this it is likely to be overlooked. Even in Alberta soil is washed away, rainfall lost, and gullies formed. What control measures are possible and are they suitable for our conditions?

PROTECTIVE COVER

Permanent Crop Cover

A permanent grass sod or plant cover of some sort with no grazing allowed may be considered as the ultimate in erosion control. Hills that are too steep for farming and which are therefore subject to rapid erosion can be controlled only in this way. There are numerous hillsides of this type in our Alberta topography. Overgrazing such areas can remove plant protection and cause serious losses of topsoil and therefore controlled grazing should be practised. In some cases such hillsides may be reserved for hay crops. Figure 16 illustrates a slope used in this way. Settlers opening up new areas and clearing new fields should consider the advisability of leaving untouched the native tree, brush, or grass cover on steep slopes. Such slopes, if brought into cultivation, seldom produce good crops and only add to the costs of farming.

If it is possible to farm the slope a variation from permanent sod is to have a rotation in which grass and hay crops predominate. Such a practice permits the growth of good hay crops as well as cash crops, but brings in the risk of losing the topsoil when the grass is plowed down and there is no plant cover. A good rotation should be followed on all fields, however, not only those with steep slopes, the object being to maintain or increase the amount of organic matter and fibre in the soil. A good rotation helps to maintain the fertility of the soil as well as helping in the control of erosion.

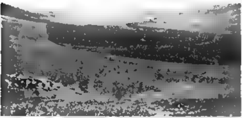


Figure 16.—On the left a contour strip too steep to cultivate is used to advantage as a hay field and pasture near Innisfail.

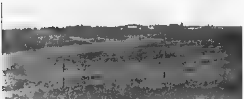


Figure 17. A grassed-in watercourse on a farm near Nisku south of Edmonton. The mat of fibre prevents gullying during spring run-off and during heavy rains.

A permanent grass sod is the logical way to prevent gullying. With manually operated tillage implements it is a chore to lift the plow or the cultivator out of the ground each time a watercourse is crossed, but with hydraulically operated machinery there is now no excuse whatever for not leaving the plant cover in a watercourse undisturbed. Figure 17 shows a grassed-in watercourse just south of Edmonton. All watercourses that receive large volumes of water in spring run-off or in summer showers are subject to gullying and should be grassed. Where possible a legume grass mixture should be used. The size of the watershed and the shape of the watercourse will determine the width of plant cover needed. For shallow courses and large watersheds a wider belt of grass is necessary than

for narrow deep coulees and small watersheds. In deciding on the width of grass strip to seed, consideration should be given also to implements to be used in caring for the strip An average total width of one and a half to two rods should be satisfactory in most cases. Having once established a grassed-in watercourse, tillage of the field should not parallel the watercourse as this sooner or later leads to gullying along the edge of the grass strip. Watercourses not grassed-in inevitably lead to gullies which are costly to repair, difficult to cross, hard on machinery, and wasteful in soil and water

Cover Crops

Recalling the value of plant cover in preventing erosion, the value of cover crops and catch crops is obvious. These are crops planted too late in the season to mature but intended for use as protection against wind and water erosion, as a supplementary pasture for livestock, or as a crop that can be turned under as a green manure Such crops, if left during the winter can help to check damage due to spring run-off such as that illustrated in **Figure 18**. The idea of a "black summerfallow" that is one without a single plant growing or a bit of stubble showing has attracted many adherents in the West Such a practice is a direct invitation to serious soil erosion by both wind and water and should be avoided wherever possible. In regions where moisture supply is a critical factor, fallowing aims at the storage of water A trash covered field will do this better than a bare soil and the trash will also prevent erosion In areas where moisture is not critical, fallowing is justified only for control of serious weeds, such as couch grass, Canada thistle, toadflax etc. Keeping the land in crops as much as

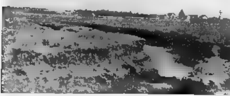


Figure 18—Result of spring run-off in 1948 northeast of Prestville, in the Peace River country

possible is not only a sure way to conserve the soil but it also means more cash returns.

Trash Cover

A trash cover means a layer of plant residues such as stubble and straw lying on the surface of the ground. As mentioned above, a trash cover is valuable in conserving moisture and in controlling erosion. A trash cover cuts down the flow of air over the soil surface and hence slows down evaporation. During heavy rains the trash protects the soil from the impact of the falling drops which otherwise would disintegrate many of the soil aggregates. Then the trash slows down any surface flow of water allowing more time for infiltration and reducing the velocity of run-off water so that danger of cutting and gullying is lessened. Figure 19 shows a fallowed field with only a small amount of trash cover and the badly washed slopes and watercourses that resulted from this lack of protection. When stubble fields are fallowed implements should be used which leave a suitable proportion of the stubble and combine straw on the surface.

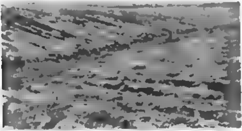


Figure 19. A badly washed field and [illegible]. Ridges left by [illegible] up and down the slope encouraged the formation of rills or small gullies.

Careful Cultural Practices

Increasing the water holding capacity and rate and amount of infiltration and thus decreasing run-off is the object to keep in mind in planning cultural methods to prevent soil erosion. How can this be done?

On our wheat farms conservation of all organic matter is essential. Stubble should not be burned, no matter how heavy the stand or how thick the straw. Proper adjustment of one-ways avoids any great difficulty in handling this organic matter. Some of it can be worked into the soil while the rest becomes a trash cover. The use of nitrogenous fertilizers on stubbled-in crops is a promising practice. The object of this fertilization is to supply micro-organisms with nitrogen needed in the processes of decomposing the straw, nitrogen which would otherwise be robbed from the growing crop.

On mixed farms there are many ways in which organic matter can be maintained or built up in the soil. Brome, timothy, creeping red fescue, crested wheat, and other grasses add fibre to the soil and if supplemented with legumes and used as green manures result in increased fertility as well as erosion control. Barnyard manure is an important source of organic matter. Spread on slopes, knolls, or in watercourses, it will do a good job of controlling erosion, both wind and water, and will also increase crop yields. On many farms in the grey-wooded soil zone peaty areas offer a tremendous supply of organic matter. Transferring some of this surplus organic matter to the light colored soils on the slopes and knolls would improve not only the peat soil, which contains too much organic matter, but also the mineral soil, which contains too little. With hydraulically operated shovels and loaders such a task is not impractical.

Certain crops are better than others in opening up tight subsoils and improving percolation rates. Sweet clover, with its long tap root, is especially good and alfalfa is good. Special machinery is now available to open up the subsoil. Proof of its value in Alberta is still lacking. Cost of operation and the fact that the aeration effect is only temporary suggest that the growth of deep rooted crops where practical may be a better practice.

The type of surface left by the implements used is an important factor affecting rate of percolation and run-off. A rough, cloddy soil, with cultivator ridges along the contour holds the rainfall much better than an overworked field smoothed and pulverized by harrowing. Cultivator ridges not on the contour encourage the formation of run-off streams and funnel them into the watercourses. Where the watercourse is not grassed in serious gullying can occur. Listing equipment, which leaves the surface covered with small collecting basins, conserves moisture and could be used to advantage in many areas. Slopes, such as those shown in Figures 20 and 21, show the need for a trash cover and the use of implements like

the cultivator, rod weeder, one-way and blade weeder that will leave the trash on top. The speed at which implements are operated, for example the one-way, should not be excessive, because this causes pulverization. Excessive working of the soil has the same effect.

Figure 20.—Overworking this slope east of Leduc buried all the trash and pulverized the soil allowing serious erosion to occur.

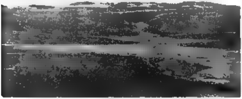


Figure 21.—Serious water erosion on this broad slope near Vermilion has washed tons of soil down on to the flat area in the right foreground.

Special Control Methods

The construction of terraces is common in countries subject to serious erosion. Terracing is not likely to be practical in Alberta, except in very special cases, until the land has increased to many times its present value. The Mangum, or broad-based terrace, would be most suitable. The use of contour strips is another specialized practice. See Figure 22. There are many farms in Alberta where a modified contour strip technique could be fol-

Figure 22. Contour strips on the Dominion Demonstration Station at Nobleford. Cultivation along the contour decreases loss of water due to run-off.

lowed. Figure 16 shows one example. Where a height of land extends across a field, the slope might well be seeded down to a strip of grass with its upper margin following the contour at the top of the slope and its lower margin in the contour at the foot. Also where there are long uniform slopes contour strips may be practical. The width would vary according to the slope and the soil. Contour strips of course add to the time, trouble, and expense of farming, and each farm must be handled differently. The Peace River and Drumheller areas have long uniform slopes where contour strips could be used but much of the hilly land elsewhere in Alberta with typical morainal topography consisting of many small rounded hills is quite unadaptable to strip cropping.

Contour furrows offer a simple means of conserving moisture and preventing run-off. This practice has proven useful in pastures and on range land in many parts of the United States and in southern Alberta. Single furrows are plowed along the contour, separate furrows being up to three or four rods apart, depending upon the degree of slope.

The construction of dams is necessary in steep gullies or watercourses carrying large streams of water in spring or during summer rains. Such dams can be of stone, pile, or brush construction. See Figures 23 and 24. Woven-wire and posts can be used for anchorage. Concrete jobs are of course more stable if well done, but are more costly. It is cheaper and easier to control watercourses before they develop into gullies than it is afterwards. Rocks or gravel can be used to prevent the cutting away of short steep slopes as in Figure 24 by covering the area with a layer or two of rocky material.

Figure 23 A rock dam in a roadside ditch near Beaverlodge intended to prevent gullying

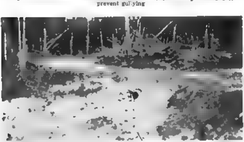


Figure 24 Rocks used to prevent cutting away of steep slopes around a culvert.

Cultivated row crops should be planted with rows across the slope rather than up and down. This would apply to gardens, potato fields, and so on.

Community Effort

Since watersheds and watercourses always extend over many farms it is essential that all members of the community do their share in controlling run-off. A water channel even if grassed in can only withstand the cutting power of a stream of water up to a certain degree and it is therefore difficult to prevent gullying unless all those concerned with the watershed do their part in checking run-off. Furthermore deposits of alluvial material can damage crops and cover roadsides as in Figure 25, causing inconvenience and trouble to neighbors.

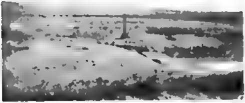


Figure 25. A [illegible] deposit washed from an adjacent fallow field near Lethbridge

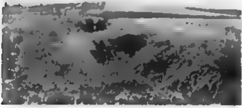


Figure 26. A gully [illegible] attention that must be given to [illegible]

Frequently community effort is needed to repair damage such as that shown in Figure 26.

Filling in gullies is a job requiring specialized equipment in many cases and most farms are not equipped for the job. Some co-operation and organization of community effort is necessary in such cases. Civic organizations can, and in some cases do, take an active part in directing such efforts and in stressing soil conservation programs. Realizing the importance of agriculture, and therefore of the soil, to our country, these organizations are simply demonstrating the fact that what is good for the farmer is good for the nation.